DEPARTMENT OF THE INTERIOR

CANADA

HON. W. J. ROCHE, *Minister.* W. W. CORY, C.M.G., *Deputy Minister.*

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# ORBITS OF THE SPECTROSCOPIC COMPONENTS OF 50 DRACONIS.

BY W. E. HARPER, M.A.

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This star ($\alpha = 18^h\ 49^m.6$, $\delta = +75°\ 19'$, photographic magnitude 5·4) was announced as a spectroscopic binary by Frost at the Evanston meeting of the American Astronomical Society. The velocities of the ten measurable plates secured at Yerkes in June and July, 1914, were made available to the writer who undertook the determination of the star's orbit. Professor Frost said that the period seemed to be about 4·2 days as the lines were double on alternate days.

The weather during September and October was very favourable and 34 spectrograms of the star, each averaging about 70 minutes exposure, were obtained before the end of the year. Of these, two have been rejected; one, for temperature changes in the prism during exposure, and the other, for the general uncertain character of the lines. The remaining 32—the measures of which are given in detail—form the basis of this publication. Seed 27 plates and the single-prism were used throughout, the dispersion at λ4325 being 32·1Å per millimetre.

The spectrum of both components is of the A-type the intensities being nearly, though not quite, equal. When the spectra are superposed a great many lines can be seen which are not recorded when the spectra are resolved. These lines are probably too weak when standing alone to appear, but when superposed they show sufficient contrast to be measurable. The following table gives the wave-lengths of the lines and the elements to which they are due.

LINES IN 50 DRACONIS.

| Element. | Wave-Length. | Element. | Wave-Length. | Element. | Wave-Length. |
|---|---|---|---|---|---|
| *Fe* | 4584·018 | *Cr Mg* | 4352·006 | *Si* | 4128·211 |
| *Fe–Ti* | 4549·766 | *Hγ* | 4340·634 | *Hδ* | 4101·890 |
| *Ti* | 4534·139 | *Fe* | 4325·939 | *Sr* | 4077·885 |
| *Fe–Ti* | 4522·871 | *Fe* | 4308·081 | *Fe* | 4071·901 |
| *Ti* | 4515·508 | *Fe* | 4294·301 | *Fe* | 4063·756 |
| *Ti* | 4508·455 | *Fe–Fe* | 4271·760 | *Fe* | 4045·975 |
| *Mg* | 4481·400 | *Fe* | 4260·640 | *Fe* | 4005·355 |
| *Ti* | 4468·663 | *Fe* | 4233·328 | *He* | 3970·177 |
| *Fe* | 4466·734 | *Fe–Ca* | 4227·010 | *Ca* | 3968·625 |
| *Fe* | 4404·927 | *Sr–Cr* | 4215·668 | *Ca* | 3933·825 |
| *Ti* | 4395·286 | *Fe* | 4143·928 | | |

It is customary to deduce corrections to the assumed wave-lengths by equating to zero the sum of the residuals of each line from the mean of the plate. Such residuals were formed in the case of 29 plates whose lines were considered free from any error due to the blending of the components but in only two cases did there seem to be a systematic error in the wave-length employed. Improvement would be effected in the agreement of the individual lines by decreasing the wave-length of the $H\gamma$ line 0·058Å and by increasing the *K* line 0·089Å but, as the lines are poor in this star and as no appreciable change would result in the velocity of the plate, the assumed wave-lengths were allowed to stand.

MEASURES OF 50 DRACONIS.

| λ | 6354 | | | | 6375 | | | | 6312 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 4549 | | | | | +57·9 | ½ | −69·9 | ½ | | | | | | |
| 4481 | | | | | 52·7 | ¾ | 85·3 | ¾ | +48·7 | ½ | −59·7 | ½ | | |
| 4340 | | | | | 38·0 | ½ | 80·7 | ½ | | | 80·7 | ¼ | | |
| 4300 | | | | | | | 109·9 | ½ | | | | | | |
| 4294 | | | | | 48·5 | ½ | | | | | | | | |
| 4233 | | | | | | | | | | | 45·9 | ¼ | | |
| 4143 | | | | | 65·4 | ¼ | 84·5 | ¼ | | | 66·8 | ½ | | |
| 4101 | | | | | 47·6 | ½ | 125·0 | ¼ | | | 44·4 | ¼ | | |
| 4077 | | | | | 56·3 | ½ | | | | | | | | |
| 4045 | | | | | 39·3 | ½ | 84·3 | ½ | 28·8 | ¾ | 66·9 | ¾ | | |
| 4005 | | | | | | | | | +36·4 | ¾ | 61·1 | ¼ | | |
| 3933 | +39·8 | ¾ | −69·8 | ¾ | +70·2 | ½ | −66·3 | ¼ | | | −55·0 | ½ | | |
| Weighted mean | + 39·80 | | − 69·80 | | + 52·17 | | − 87·56 | | + 36·62 | | − 61·22 | | | |
| $V_4$ | + 4·89 | | + 4·89 | | + 4·80 | | + 4·80 | | + 4·77 | | + 4·77 | | | |
| $V_2$ | − ·05 | | − ·05 | | − ·01 | | − ·01 | | − ·02 | | − ·02 | | | |
| Curv. | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | | |
| Radial Velocity | + 44·4 | | − 65·2 | | + 56·7 | | − 83·0 | | + 41·1 | | − 56·8 | | | |

MEASURES OF 50 DRACONIS—*Continued.*

| λ | 6390 | | | | 6398 | | | | 6405 | | | | 6408 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 454 | | | | | | | | | | | | | − 7·2 | ½ |
| 4481 | | | | | + 26·6 | ¾ | − 59·4 | ½ | + 62·6 | ½ | | | − 23·6 | ½ |
| 4340 | | | − 91·4 | ½ | | | | | 54·2 | 1 | − 90·3 | ½ | − 21·6 | ½ |
| 4233 | | | | | | | | | 66·5 | ¼ | | | − 19·7 | ¼ |
| 4101 | + 50·2 | ½ | 85·6 | ½ | 38·0 | ½ | 77·0 | ¼ | | | 80·0 | ¼ | | |
| 4071 | | | | | | | 63·8 | ¼ | | | | | | |
| 4063 | | | | | 35·1 | ¼ | 60·0 | ¼ | 49·9 | ¼ | 83·8 | ¼ | + 20·4 | ½ |
| 4045 | | | | | 24·9 | ¼ | 65·3 | ¼ | | | 84·1 | ½ | + 29·9 | ¼ |
| 4005 | | | | | | | | | | | | | + 24·6 | ½ |
| 3933 | + 62·0 | ¼ | − 76·6 | 1 | + 35·4 | ½ | − 65·1 | ¾ | + 55·1 | ¾ | − 85·8 | ¾ | − 26·8 | ½ |
| Weighted mean | + 54·13 | | − 82·55 | | + 31·84 | | − 64·46 | | + 56·70 | | − 85·56 | | − 4·15 | |
| $V_a$ | + 4·73 | | + 4·73 | | + 4·70 | | + 4·70 | | + 4·68 | | + 4·68 | | + 4·65 | |
| $V_a$ | − ·02 | | − ·02 | | − ·04 | | − ·04 | | − ·02 | | − ·02 | | − ·04 | |
| Curv. | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | |
| Radial Velocity | + 58·6 | | − 78·1 | | + 36·2 | | − 60·1 | | + 61·1 | | − 81·2 | | + 0·2 | |

MEASURES OF 30 DRACONIS.—*Continued*

| λ | 6414 | | | | 6421 | | 6424 | | | | 6437 | | 6445 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 4563 | | | | | | | | | | | | | − 8·0 | ½ |
| 4549 | | | | | − 9·2 | ½ | | | | | − 21·6 | ¾ | 41·0 | ¾ |
| 4508 | | | | | | | | | | | | | 23·2 | ½ |
| 4501 | | | | | | | | | | | | | 27·9 | ½ |
| 4481 | + 68·3 | ¼ | − 80·0 | ¼ | − 8·5 | ¼ | + 68·7 | ½ | − 84·0 | ½ | − 15·1 | 1 | 29·1 | 1 |
| 4468 | | | | | | | 52·5 | ¼ | 105·6 | ¼ | + 1·7 | ½ | | |
| 4466 | | | | | | | | | | | − 1·8 | ½ | | |
| 4404 | | | | | | | | | | | + 2·0 | 1 | | |
| 4395 | | | | | | | | | | | − 4·0 | ½ | | |
| 4383 | | | | | + 19·9 | ½ | | | | | − 24·8 | ½ | | |
| 4352 | | | | | | | | | | | | | | |
| 4340 | 68·5 | ¼ | 82·9 | ¼ | − 8·7 | ¼ | 78·0 | ½ | 80·7 | ½ | − 15·9 | ¾ | 30·9 | ½ |
| 4308 | | | | | | | 82·7 | ½ | | | | | 30·8 | ½ |
| 4271 | | | | | | | | | | | − 31·4 | ½ | | |
| 4250 | | | | | | | | | | | − 14·2 | ½ | | |
| 4233 | 88·0 | ½ | | | | | 93·3 | ¼ | | | − 11·9 | ¾ | 21·5 | ½ |
| 4227 | | | | | | | | | | | | | | |
| 4215 | | | | | | | | | | | − 26·3 | ½ | 18·2 | ¾ |
| 4143 | | | | | | | | | | | − 19·0 | ¾ | | |
| 4128 | | | | | | | | | | | | | 15·3 | 1 |
| 4101 | | | | | − 37·0 | ¼ | 52·1 | ½ | 67·0 | ½ | | | | |
| 4077 | | | | | | | 64·5 | ¼ | 78·5 | ¼ | − 20·7 | 1 | 33·1 | ½ |
| 4071 | | | | | | | 62·1 | ¼ | | | − 5·9 | ½ | 27·3 | ½ |
| 4063 | 53·7 | ¼ | 75·7 | ¼ | | | | | 90·2 | ½ | | | 24·2 | ¾ |
| 4045 | | | | | | | | | 100·1 | ¼ | − 10·9 | 1 | 26·1 | 1 |
| 3933 | + 68·7 | ¼ | − 94·3 | ¼ | + 11·2 | ¼ | + 86·8 | ¾ | − 85·3 | ¾ | − 6·8 | ¾ | − 14·6 | ¾ |
| Weighted mean | + 72·53 | | − 83·22 | | − 2·70 | | + 73·05 | | − 84·56 | | − 13·29 | | − 23·68 | |
| $V_0$ | + 4·71 | | + 4·71 | | + 4·58 | | + 4·50 | | + 4·50 | | + 4·40 | | + 4·33 | |
| $V_1$ | − ·01 | | − ·01 | | − ·03 | | − ·01 | | − ·01 | | − ·01 | | − ·05 | |
| Curv. | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | |
| Radial Velocity | + 76·9 | | − 78·8 | | + 1·6 | | + 77·2 | | − 80·4 | | − 9·2 | | − 19·7 | |

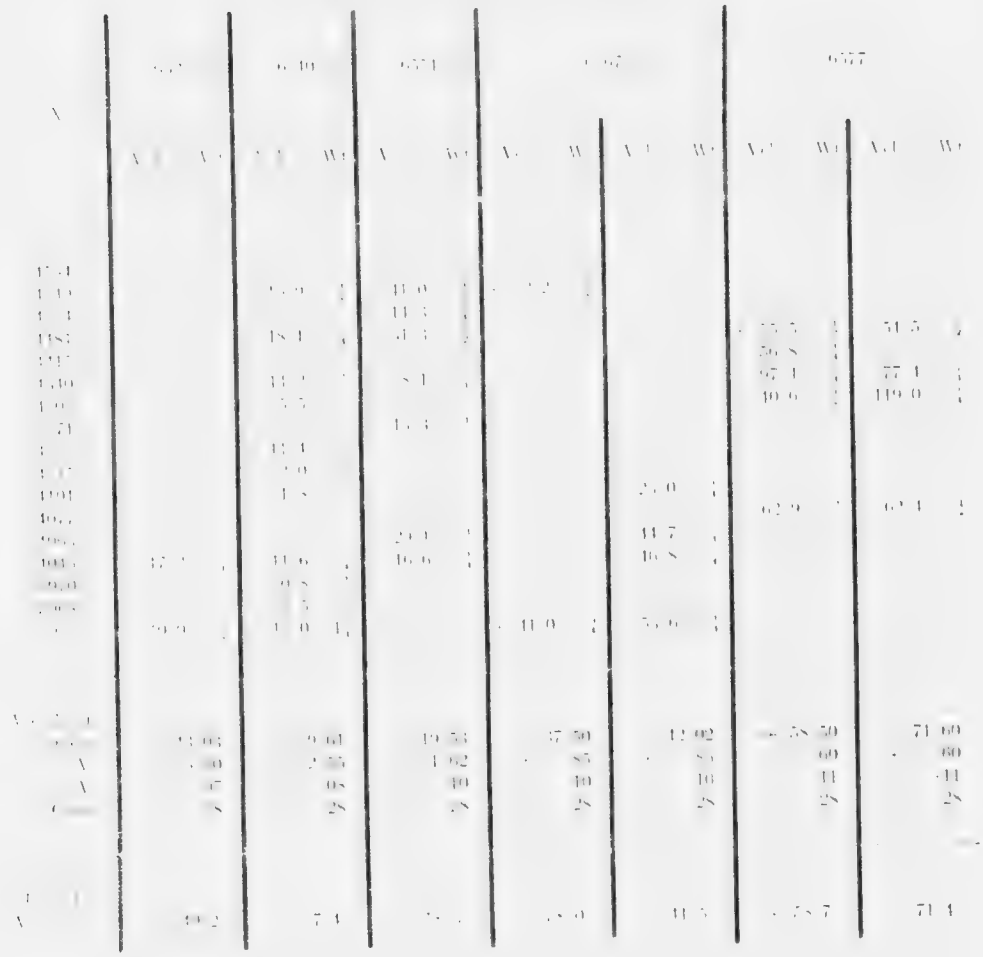
MEASURES OF 30 DRACONIS.—*Continued.*

| λ | 6452 | | | | 6463 | | 6473 | | | | 6476 | | 6491 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. | Vel. | Wt. |
| 4584 | | | | | − 32·1 | ¼ | | | | | − 47·6 | ½ | | |
| 4549 | | | | | − 14·8 | ¾ | | | −105·9 | ¾ | 15·6 | ¾ | − 29·8 | ¾ |
| 4522 | | | | | | | | | 87·5 | ½ | | | | |
| 4481 | | | | | − 7·1 | ½ | + 41·4 | ¾ | 95·1 | ¾ | 13·8 | ¾ | 15·7 | ½ |
| 4352 | | | | | + 2·7 | ¼ | | | | | | | | |
| 4340 | + 60·0 | ¼ | − 98·0 | ¼ | − 13·5 | 1 | 61·4 | ½ | 122·3 | ½ | 17·7 | ¾ | | |
| 4325 | | | | | − 21·2 | ½ | | | | | 14·4 | ½ | | |
| 4308 | | | | | | | | | | | 8·5 | ½ | | |
| 4271 | | | | | − 30·9 | ½ | | | | | | | | |
| 4260 | | | | | − 12·2 | ½ | | | | | | | | |
| 4233 | 60·8 | ¾ | | | − 3·2 | ¾ | | | | | | | 1·9 | ½ |
| 4215 | | | | | | | | | | | 15·1 | ½ | | |
| 4143 | 60·9 | ½ | | | − 19·9 | ½ | 69·2 | ½ | | | | | | |
| 4101 | 48·0 | ½ | 106·1 | ½ | − 15·6 | ¼ | 83·0 | ½ | 68·0 | ¼ | 23·9 | ½ | 34·1 | ¼ |
| 4077 | | | | | − 12·2 | ½ | | | | | 15·0 | ½ | | |
| 4071 | | | | | − 24·0 | ¾ | | | | | | | | |
| 4063 | 70·7 | ¾ | | | − 14·0 | ¾ | | | | | | | | |
| 4045 | | | 91·1 | ¾ | − 18·5 | 1 | | | 86·1 | ½ | | | | |
| 3933 | + 71·9 | ½ | − 78·6 | ½ | − 10·4 | ¾ | + 67·6 | ¾ | − 96·5 | ¾ | − 8·1 | ½ | − 34·2 | ½ |
| Weighted mean | + 62·80 | | − 92·70 | | − 15·26 | | + 62·85 | | − 97·02 | | − 17·67 | | − 22·71 | |
| $V_3$ | + 4·30 | | + 4·30 | | + 4·27 | | + 4·23 | | + 4·23 | | + 4·20 | | + 3·90 | |
| $V_4$ | − ·02 | | − ·02 | | − ·03 | | − ·03 | | − ·03 | | − ·02 | | − ·10 | |
| Curv. | − ·28 | | − 28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | |
| Radial Velocity | + 66·8 | | − 88·7 | | − 11·3 | | + 66·8 | | − 93·1 | | − 13·8 | | − 19·2 | |

MEASURES OF 50 DRACONIS. *Continued*

| λ | 6495 | | | | 6502 | | | | 6519 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt | Vel. | Wt | Vel. | Wt | Vel. | Wt | Vel. | Wt | Vel. | Wt | Vel. | Wt |
| 4519 | + 44·6 | ¼ | − 86·1 | ¼ | | | | | | | | | | |
| 4481 | 76·6 | ¼ | 53·1 | ¼ | ..... | .. | ..... | .. | + 48·1 | ½ | − 95·3 | ¼ | | |
| 4340 | 25·6 | ½ | 97·3 | ¼ | ..... | ... | ..... | ... | 60·3 | 1 | 93·2 | 1 | | |
| 4315 | 53·3 | ½ | | | | | | | | | | | | |
| 4308 | 58·6 | 1 | 93·7 | ½ | | | | | | | | | | |
| 4271 | ..... | .. | 84·5 | ¼ | | | | | | | | | | |
| 4233 | ..... | .. | ..... | ... | + 25·4 | ½ | | | | | | | | |
| 4101 | ..... | .. | ..... | ... | 29·2 | ½ | − 54·8 | ¼ | | | | | | |
| 4063 | 46·5 | ¼ | 60·0 | ¼ | | | | | | | | | | |
| 4045 | ..... | .. | 86·2 | ¼ | ..... | .. | ..... | ... | 54·5 | ¼ | 85·0 | ¼ | | |
| 3968 | | | | | | | | | | | 75·2 | ¼ | | |
| 3933 | + 45·6 | ¼ | − 63·7 | ¼ | + 31·6 | ½ | − 62·5 | ½ | + 51·8 | 1 | 77·0 | 1 | | |
| Weighted mean | + 50·12 | | − 78·73 | | + 28·73 | | − 59·93 | | + 56·31 | | − 85·12 | | | |
| $V_4$ | + 3·84 | | + 3·84 | | + 3·78 | | + 3·78 | | + 3·27 | | − 3·27 | | | |
| $V_6$ | − ·05 | | − ·05 | | − ·05 | | − ·05 | | − ·04 | | ·04 | | | |
| Curv. | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | − ·28 | | | |
| Radial Velocity | + 53·9 | | − 75·2 | | + 32·2 | | − 56·5 | | + 59 | | − 82·2 | | | |

MEASURES OF 70 DRACONIS



MEASURES OF 50 DRACONIS.

| λ | 6578 | | 6584 | | | | 6602 | | | | 6622 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V–I | W | V–I | W | V–I | W | V–I | W | V–I | W | V–I | W | V– | W |
| 1584 | | | | | | | + 51·8 | 4 | 177·9 | | | | | |
| 1510 | ... | | + 86·2 | 1 | – 76·1 | 1 | 51 · | 4 | 94·3 | | | | | |
| 1181 | – 1·0 | 1 | ... | | 93·9 | 1 | 50·8 | | 90·8 | | 59·2 | 1 | 86·3 | 1 |
| 1130 | 13·1 | 1 | 94·2 | 1 | 88·1 | 1 | 52·7 | | 94·1 | | 58·6 | 1 | 92·8 | |
| 1108 | ..... | | 65·1 | 1 | 101·2 | | | | | | | | 89·8 | |
| 1271 | .... | | 95·7 | 1 | ..... | | 61·7 | | 98·8 | | | | 93·4 | |
| 1260 | .... | | 71·0 | | | | | | | | | | | |
| 1101 | 25·6 | 1 | ..... | | .... | | 98·7 | | 88 · | | 60 · | 1 | | |
| 1077 | .... | | 65·1 | 1 | | | | | | | | | | |
| 1071 | 26·3 | 1 | | | | | | | | | | | | |
| 1063 | ... | | 69·3 | | | | | | | | | | | |
| 1015 | 8·2 | 1 | + 70·9 | 1 | – 81·6 | 1 | | | 100·0 | 1 | | | | |
| 0933 | – 7·2 | 1 | | | ... | | + 80·0 | 1 | 87·7 | 1 | + 70·2 | 1 | – 94·8 | 1 |
| Weighted mean | – 11·33 | | + 78·61 | | – 84·80 | | + 57·07 | | – 90·57 | | + 59·18 | | – 90·73 | |
| $V_0$ | + ·52 | | – ·11 | | – ·11 | | – ·27 | | ·27 | | – 99 | | – 99 | |
| $V_1$ | 10 | | – ·11 | | – ·11 | | – ·10 | | 10 | | – 10 | | – 10 | |
| Corv. | – ·28 | | – ·28 | | – ·28 | | – ·28 | | ·28 | | ·28 | | – ·28 | |
| Radial Velocity | 11·2 | | + 78·4 | | – 85·3 | | + 56·4 | | 97·0 | | + 58·1 | | + 92·1 | |

MEASURES OF 50 DRACONIS.

| λ | 6624 | | 6634 | | | | 6659 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vel. | Wt | Vel. | Wt | Vel. | Wt | Vel. | Wt | Vel. | Wt | Vel. | Wt | Vel. | Wt |
| 4549 | − 7·5 | ¾ | | | | | − 74·2 | ½ | | | | | | |
| 4481 | + 8·5 | ¾ | + 66·6 | 1 | | | | | | | | | | |
| 4415 | | | | | | | 59·0 | ½ | | | | | | |
| 4340 | − 5·4 | ½ | 72·7 | ½ | − 97·0 | ½ | | | | | | | | |
| 4233 | | | | | | | 43·9 | ¼ | | | | | | |
| 4101 | − 20·2 | ¼ | 39·7 | ½ | 91·4 | ½ | | | | | | | | |
| 4045 | | | 39·6 | ¼ | 73·6 | ¼ | 47·0 | ¼ | | | | | | |
| 4005 | | | | | | | 40·4 | ¼ | | | | | | |
| 3968 | | | 45·4 | ½ | 79·8 | ½ | | | | | | | | |
| 3933 | − 6·5 | ¾ | + 70·4 | ¾ | − 77·0 | ¾ | − 47·0 | ½ | | | | | | |
| Weighted mean | − 3·64 | | + 59·44 | | − 84·12 | | − 54·68 | | | | | | | |
| $V_1$ | 4·10 | | − 1·16 | | − 1·16 | | − 1·92 | | | | | | | |
| $V_2$ | − ·11 | | − ·11 | | − ·11 | | − ·10 | | | | | | | |
| Curv. | − ·28 | | − ·28 | | − ·28 | | − ·28 | | | | | | | |
| Radial Velocity | 5·1 | | + 57·9 | | − 85·7 | | − 57·0 | | | | | | | |

The following table contains all the data of the measures. The phases are reckoned from the periastron finally adopted J. D. 2420293·930 using the period 4·120 days. The number of lines measured and the weight assigned each plate follow. The residuals O-C are scaled from the curve representing the adopted elements. They are given only for those plates whose lines are fully resolved. Corresponding data is given for the Yerkes' observations.

TABLE OF MEASURES OF 50 DRACONIS

| Plate. | Observer* | Date. | Julian Date | Phase | Component I. | | | | Component II | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | n | Wt. | Vel. | O-C. | n | Wt. | Vel. | O-C |
| | | 1911 | | | | | | | | | | |
| 6354 | P | Sept. 11. . | 2420387·607 | 3·037 | 1 | 1 | + 44·4 | +9·0 | 1 | 1 | − 65·2 | − 7·2 |
| 6375 | Y | Sept. 15 .... | 391·523 | 2·833 | 9 | 6 | + 56·7 | +9·7 | 8 | 5 | − 83·0 | −10·0 |
| 6382 | G | Sept. 16 .... | 392·535 | 3·845 | 8 | 5·5 | − 56·8 | −1·8 | 3 | 2·5 | + 41·1 | +1·1 |
| 6390 | H | Sept. 17 .... | 393·522 | ·712 | 3 | 2·5 | − 78·1 | −5·3 | 2 | 1·5 | + 58·6 | − 1·4 |
| 6398 | C | Sept. 18 .... | 394·577 | 1·767 | 6 | 4 | + 36·2 | +2·0 | 5 | 3·5 | − 60·1 | − 1·1 |
| 6405 | H | Sept. 19 .... | 395·523 | 2·713 | 5 | 4 | + 61·1 | +2·6 | 5 | 3·5 | − 81·2 | + 2·0 |
| 6408 | Y | Sept. 20 .... | 396·563 | 3·753 | 8 | 5·5 | + 0·2 | | | | | |
| 6414 | H | Sept. 21.... | 397·564 | ·634 | 5 | 3 | − 78·8 | −0·8 | 4 | 2 | + 76·9 | −11·9 |
| 6421 | Y | Sept. 22 .... | 398·542 | 1·612 | 6 | 4 | + 1·6 | | | | | |
| 6424 | P¹ | Sept. 25 .... | 401·542 | ·492 | 8 | 5·5 | − 80·4 | +4·6 | 9 | 6 | + 77·2 | + 5·0 |
| 6437 | P¹ | Sept. 28 .... | 401·531 | 3·481 | 17 | 12 | − 9·2 | | | | | |
| 6445 | G | Sept. 30 .... | 406·570 | 1·400 | 16 | 11 | − 19·7 | | | | | |
| 6452 | H | Oct. 1..... | 407·504 | 2·334 | 6 | 4·5 | + 66·8 | +3·4 | 4 | 3 | − 88·7 | + 2·7 |
| 6463 | C | Oct. 2..... | 408·514 | 3·344 | 16 | 11 | − 11·3 | | | | | |
| 6473 | P | Oct. 3..... | 409·510 | ·220 | 7 | 5·5 | − 93·1 | −6·7 | 5 | 4 | + 66·8 | − 6·8 |
| 6476 | Y | Oct. 4 .... | 410·490 | 1·200 | 10 | 7 | − 13·8 | | | | | |
| 6491 | G | Oct. 12 ... | 418·539 | 1·009 | 5 | 3·5 | − 19·2 | | | | | |
| 6495 | Y | Oct. 13 .... | 419·503 | 1·973 | 7 | 5 | + 53·9 | +4·3 | 8 | 4 | − 75·2 | + 0·2 |
| 6502 | P¹ | Oct. 14 .... | 420·516 | 2·986 | 3 | 2 | + 32·2 | −5·0 | 2 | 1·5 | − 56·5 | + 6·0 |
| 6519 | H | Oct. 22..... | 428·478 | 2·708 | 4 | 3 | + 59·3 | +1·3 | 5 | 4 | − 82·2 | + 1·2 |
| 6528 | C | Oct. 23. .... | 429·510 | 3·740 | 2 | 1·5 | − 40·2 | | | | | |
| 6540 | P | Nov. 2..... | 439·517 | 1·387 | 11 | 8 | − 7·4 | | | | | |
| 6554 | P | Nov. 14..... | 451·513 | 1·023 | 7 | 5 | − 18·3 | | | | | |
| 6567 | C | Nov. 23.... | 460·483 | 1·753 | 1 | 1 | + 38·0 | +5·0 | 1 | 0·5 | − 41·5 | +15·7 |
| 6577 | H | Nov. 26..... | 463·550 | ·700 | 4 | 2·5 | − 71·4 | +2·0 | 5 | 3·5 | + 58·7 | − 2·0 |
| 6578 | C | Nov. 27.. | 464·485 | 1·635 | 6 | 4 | − 11·2 | | | | | |
| 6589 | C | Dec. 4 . | 471·497 | ·407 | 5 | 3·5 | − 85·3 | +1·3 | 8 | 5 | + 78·1 | + 3·7 |
| 6602 | Y | Dec. 6.... | 473·451 | 2·361 | 7 | 4 | + 56·4 | −7·4 | 8 | 5 | − 97·0 | − 5·0 |
| 6622 | P¹ | Dec. 14 ... | 481·517 | 2·187 | 4 | 3 | + 58·1 | −1·5 | 5 | 3·5 | − 92·1 | − 4·7 |
| 6624 | Y | Dec. 15..... | 482·500 | 3·170 | 5 | 3·5 | − 5·1 | | | | | |
| 6634 | H | Dec. 16..... | 483·520 | ·070 | 5 | 3·5 | − 85·7 | −4·3 | 6 | 4·5 | + 57·9 | −10·8 |
| 6659 | H | Dec. 25 .... | 492·562 | ·872 | 6 | 3 | − 57·0 | +2·6 | | | | |

*P = Plaskett; Y = Young; G = Gibson; H = Harper; P¹ = Parker; C = Cannon.

YERKES' OBSERVATIONS, 30 DRACONIS

| Date | Julian Day | Phase | Component I | | | Component II | | |
|---|---|---|---|---|---|---|---|---|
| | | | Vel. | O-C | n | Vel. | O-C | |
| 1913 | | | | | | | | |
| June 9 | 2420293·930 | 3·95 | 5 | − 71 | − 4 | 5 | + 48 | − 5 |
| June 15 | 299 693 | 1·64 | 3 | − 28 | | | | |
| June 16 | 300 654 | 2·60 | 4 | + 84 | +23 | 4 | − 92 | − 1 |
| June 17 | 301·677 | 3·62 | 5 | 5 | | | | |
| June 22 | 306 725 | 0·43 | 2 | − 80 | + 6 | 2 | + 78 | + 1 |
| June 29 | 313 807 | 3·40 | 4 | − 6 | | | | |
| July 2 | 316 637 | 2·11 | 4 | + 73 | +17 | 3 | − 82 | + 2 |
| July 3 | 317·680 | 3·15 | 3 | + 29 | | | | |
| July 20 | 334 661 | 3·65 | 6 | + 4 | | | | |
| July 21 | 335·626 | 0·50 | 1 | − 68 | +17 | 2 | + 95 | +23 |

Comparison of Yerkes' observations with our own indicated a period of 4·120 days. No attempt was made to improve this value by least-squares.* The Ottawa plates were grouped on the basis of phases into the following normal places. Nos. 1–10 refer to Component I, Nos. 11–20 to Component II.

*Further observations will be used to improve the value.

NORMAL PLACES

| No | Mean Phase | Mean Vel. | Wt. | O-C | Eq.-Epl. |
|---|---|---|---|---|---|
| 1 | 3·45 | − 7·9 | 1·5 | + 3·8 | −·1 |
| 2 | 3·85 | − 33·2 | ·7 | + 3·3 | ·0 |
| 3 | ·31 | − 86·2 | 1·8 | + 1·3 | ·0 |
| 4 | ·74 | − 70·2 | 1·0 | + 1·1 | ·1 |
| 5 | 1·33 | − 13·4 | 2·0 | − 1·2 | −·1 |
| 6 | 1·77 | + 36·8 | ·5 | + 2·9 | −·1 |
| 7 | 1·97 | + 54·0 | ·5 | + 4·9 | ·2 |
| 8 | 2·30 | + 60·9 | 1·2 | − 2·2 | +·1 |
| 9 | 2·77 | + 58·3 | 1·3 | + 4·8 | +·1 |
| 10 | 3·00 | + 36·3 | ·3 | − 0·3 | +·1 |
| 11 | 3·45 | − 7·9 | 1·5 | + 0·3 | +·1 |
| 12 | 3·85 | + 40·7 | ·3 | − 0·1 | +·1 |
| 13 | ·32 | + 70·9 | 2·0 | − 4·0 | ·0 |
| 14 | ·67 | + 67·9 | 1·0 | + 5·6 | ·0 |
| 15 | 1·33 | − 13·4 | 2·0 | − 5·6 | −·1 |
| 16 | 1·77 | − 58·0 | ·5 | + 0·3 | ·0 |
| 17 | 1·97 | − 75·2 | ·4 | + 0·1 | ·0 |
| 18 | 2·30 | − 93·3 | 1·2 | − 2·7 | ·0 |
| 19 | 2·75 | − 82·3 | 1·2 | − 1·0 | ·0 |
| 20 | 3·00 | − 60·0 | ·3 | + 1·4 | −·1 |

The plates, where the lines were not fully resolved, were grouped into two groups about the crossing points, care having previously been taken to have the plates balanced in phase on either side of these points. The two groups thus formed were each subdivided into two, (Nos. 1 and 11, 5 and 15), half the weight being assigned to each, and the residuals from each curve taken in the solution. No great objection can be taken to this as the grouped observations refer equally to both components and for all practical purposes the intensities of the component spectra are the same.

It was seen that the eccentricity was very small, though from a few preliminary trials there was no doubt of there being a slight eccentricity. The value of $\omega$ could be stated as lying somewhere between 120° and 240°, but it was hard to state from graphical methods just what value in this interval suited best. Recourse was had to the method of least-squares, and the resulting value of $\Sigma pvv$ was lowest for $\omega_1 = 151°$, though $\omega_1 = 203°$ was a good second. A least-squares solution was also carried through for $e = 0$. The results were:—

For $e = 0$ $\Sigma pvv = 271$
For $\omega_1 = 203°$ $\Sigma pvv = 230$
For $\omega_1 = 151°$ $\Sigma pvv = 226$

The observation and normal equations for the latter only will be given. In this case $T$ had to be fixed, otherwise the solution became indeterminate. The preliminary values adopted were:—

$P = 4 \cdot 120$ days
$e = \cdot 03$
$\omega_1 = 150°$
$\omega_2 = 330°$
$K_1 = 75$ km.
$K_2 = 82 \cdot 1$ km.
$\gamma = -11 \cdot 0$ km.
$A_1 = 73$
$B_1 = 77$
$A_2 = 84 \cdot 3$
$B_2 = 79 \cdot 9$
$T =$ J. D. 2420293·93

The following substitutions were made and the equations resulting from both components were combined* into one set of normals:—

$x = \delta\gamma$
$y = \delta K_1$
$z = \delta K_2$
$u = 100\ \delta e$
$v = 100\ \delta\omega$

*Publications of the Dominion Observatory, Vol. I, No. 11, p. 327.

OBSERVATION EQUATIONS 50 DRACONIS.

| — | $x$ | $y$ | $z$ | $u$ | $v$ | $-n$ | Wt. |
|---|---|---|---|---|---|---|---|
| 1 | 1·000 | ..... | ..... | + ·678 | − ·739 | − 3·1=0 | 1·5 |
| 2 | 1·000 | − ·600 | ..... | − ·123 | − ·603 | − 2·8 | 0·7 |
| 3 | 1·000 | −1·026 | ..... | − ·667 | − ·006 | − 1·8 | 1·8 |
| 4 | 1·000 | − ·827 | ..... | + ·181 | + ·460 | − 2·0 | 1·0 |
| 5 | 1·000 | − ·040 | ..... | + ·651 | + ·761 | − 0·6 | 2·0 |
| 6 | 1·000 | + ·563 | ..... | − ·165 | + ·617 | − 5·6 | 0·5 |
| 7 | 1·000 | + ·768 | ..... | − ·536 | + ·466 | − 7·4 | 0·5 |
| 8 | 1·000 | + ·958 | ..... | − ·739 | + ·144 | − 0·1 | 1·2 |
| 9 | 1·000 | + ·849 | ..... | − ·030 | − ·352 | − 5·7 | 1·3 |
| 10 | 1·000 | + ·634 | ..... | + ·452 | − ·552 | + 0·2 | 0·3 |
| 11 | 1·000 | ..... | ..... | − ·742 | + ·809 | − 3·1 | 1·5 |
| 12 | 1·000 | ..... | + ·600 | + ·135 | + ·660 | − 2·5 | 0·3 |
| 13 | 1·000 | ..... | +1·026 | + ·715 | − ·008 | + 2·3 | 2·0 |
| 14 | 1·000 | ..... | + ·879 | − ·048 | − ·441 | − 6·8 | 1·0 |
| 15 | 1·000 | ..... | + ·040 | − ·712 | − ·833 | + 5·6 | 2·0 |
| 16 | 1·000 | ..... | − ·563 | + ·181 | − ·676 | + 0·7 | 0·5 |
| 17 | 1·000 | ..... | − ·768 | + ·587 | − ·511 | + 1·1 | 0·4 |
| 18 | 1·000 | ..... | − ·958 | + ·808 | − ·158 | + 3·6 | 1·2 |
| 19 | 1·000 | ..... | − ·862 | + ·079 | + ·365 | + 0·5 | 1·2 |
| 20 | 1·000 | ..... | − ·634 | − ·495 | + ·604 | − 3·1 | 0·3 |

NORMAL EQUATIONS.

$$\begin{aligned}
21{\cdot}200x - {\cdot}065y + {\cdot}229z + {\cdot}199u - {\cdot}295v - 19{\cdot}540 &= 0\\
5{\cdot}446y \quad\quad\quad\quad + {\cdot}033u - {\cdot}151v - 3{\cdot}839 &= 0\\
5{\cdot}496z + {\cdot}244u - {\cdot}314v - 5{\cdot}862 &= 0\\
7{\cdot}144u - {\cdot}050v + 4{\cdot}038 &= 0\\
6{\cdot}346v - 10{\cdot}610 &= 0
\end{aligned}$$

From these equations resulted the corrections,

$$\begin{aligned}
x &= +0{\cdot}94\\
y &= +0{\cdot}77\\
z &= +1{\cdot}16\\
u &= -0{\cdot}622\\
v &= +1{\cdot}786
\end{aligned}$$

One solution was seen to be sufficient, as the differences between equation and ephemeris residuals were very small.

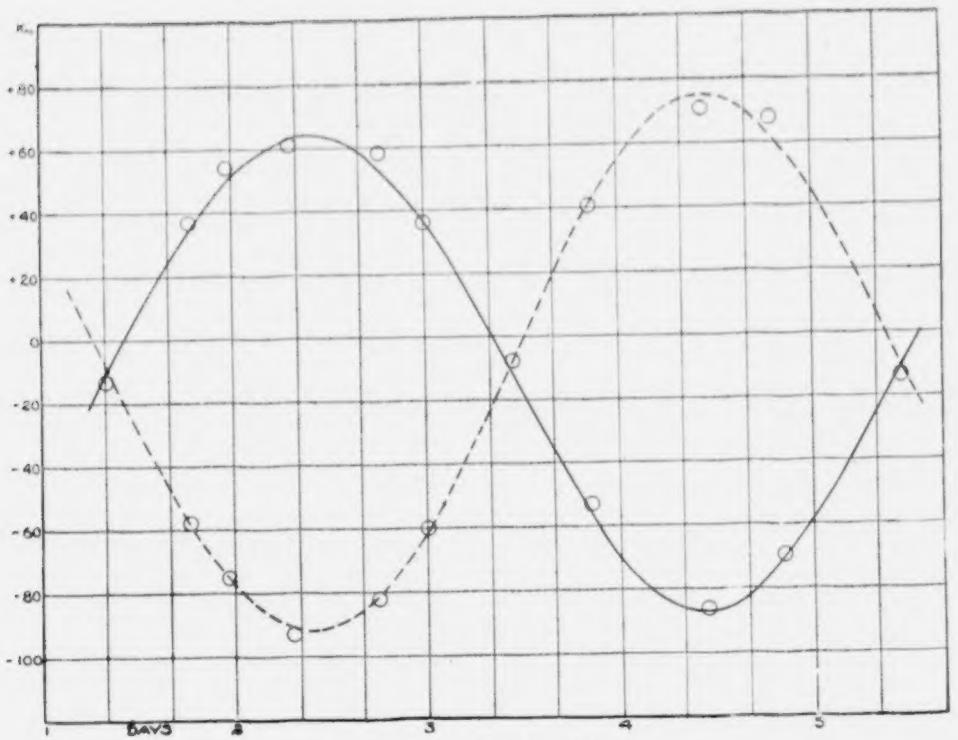
The final values of the elements with their probable errors are, then, as follows:—

$P$ = 4·120 days
$e$ = ·024 ± ·001
$K_1$ = 75·77 km. ± 1·57 km.
$K_2$ = 83·26 km. ± 1·56 km.
$\gamma$ = −10·1 km ± 0·8 km.
$\omega_1$ = 151°·0 ± 0°·8
$\omega_2$ = 331°·0 ± 0°·8
$T$ = J. D. 2420293·930

$A_1$ = 74·18 km.
$B_1$ = 77·36 km.
$A_2$ = 85·01 km.
$B_2$ = 81·51 km.
$a_1 \sin i$ = 4291000 km.
$a_2 \sin i$ = 4716000 km.
$m_1 \sin^3 i$ = 0·90⊙
$m_2 \sin^3 i$ = 0·82⊙

The graph accompanying represents the final elements and the observations as grouped. The probable error of a plate is ±3·7 km. per second.

Dominion Observatory,
Ottawa,
February, 1915.




VELOCITY CURVE OF 50 DRACONIS.